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A PRELIMINARY EVALUATION OF THE CIL DEEP SHAFT/FLOTATION PROCESS AT PARIS, ONTARIO

August 1978

Ministry
of the
Environment

Ontario

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Ref 73010

A PRELIMINARY EVALUATION OF THE CIL DEEP SHAFT/FLOTATION PROCESS AT PARIS, ONTARIO

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August, 1978

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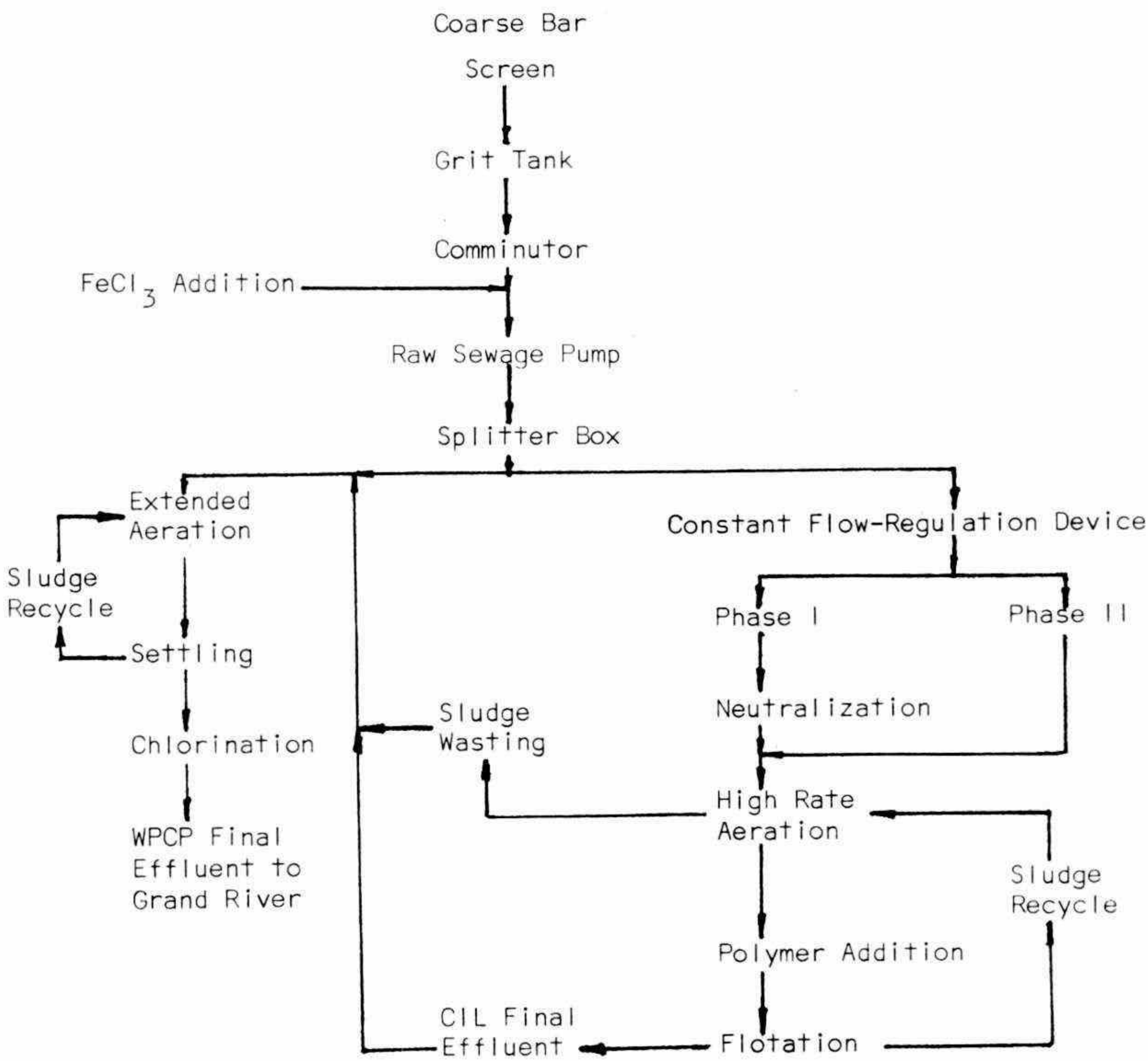
1.0 INTRODUCTION

Initial work at Billingham, England by Imperial Chemical Industries (ICI) on the synthesis of single cell protein, resulted in the development of novel concepts for application to sewage treatment. These unique factors, currently being applied in an activated sludge system at Paris, Ontario, are aeration in a vertical shaft 152 meters (500 feet) deep, and secondary clarification by flotation.

Canadian Industries Limited (CIL) have the North American rights which are marketed by Eco Research Ltd., a subsidiary of CIL. In order to obtain Ontario Ministry of the Environment (MOE) approval for use of the "Deep Shaft" process to treat municipal wastes, CIL decided to build a demonstration and research plant in the Province. In June, 1975, J.D. Lee Engineering Ltd. approached the MOE West Central Region on behalf of CIL, with the idea of installing the plant on the grounds of the Paris, Ontario Water Pollution Control Plant (WPCP). CIL would build, own, debug, operate, experiment with and demonstrate a 10.5 l/sec (200,000 gpd) deep shaft plant using as feed, a flow split from the influent to the Paris WPCP. Subsequently, "experimental approval" was given by the MOE and the demonstration facilities were constructed at CIL's expense. One reason behind the selection of the Paris site was the need for expansion of the WPCP. If the Deep Shaft process was successful, it could later be purchased as the WPCP expansion.

The Paris WPCP is an extended aeration mechanical plant; it has no primary clarification, and it has a conventional secondary clarifier. In contrast, the CIL plant has high rate diffused aeration and solids separation by flotation. Schematics for each process are presented in Figure 1. It should be noted that due to the experimental nature of

FIGURE I: Process Diagram of MOE and CIL Treatment Plants at Paris



the CIL plant, the deep shaft process effluent is returned to the Paris WPCP aeration tank.

In order to assess the treatment potential of the deep shaft/flotation process (Deep Shaft Process) at Paris, the MOE conducted a preliminary study at the demonstration plant. The study was done by the Wastewater Treatment Section (WWT) of the MOE, Pollution Control Branch. This study concentrated on assessing influent and effluent quality and treatment efficiency. Some data on the type and quantity of sludge produced was also gathered; together with information on the power, chemicals and labour required to operate the process. It is emphasized that the study and the present report deal only with the Deep Shaft Process as constructed and operated at Paris, Ontario.

Detailed results relating to the performance of individual process units were not gathered since the study was of a preliminary nature. The process was regarded as a black box with measurable "inputs" and "outputs".

In the following report, the first part (Sections 1-4) reviews project history and study objectives, and describes the Deep Shaft system installed at Paris. This is followed by an account of Phase I of the study and its conclusions (Section 5). Phase I included an evaluation of both the Deep Shaft Process and the Paris WPCP. During Phase I, the Deep Shaft Process was treating sewage of a quality which is typical at the Town of Paris. The balance of the report relates only to the Deep Shaft Process. Sections 6 and 7 include an account of the Phase II evaluation when the process was treating basically domestic sewage. This is followed by a comparison of the results from Phases I and II. Overall conclusions and recommendations follow.

Appendices have been included at the end of the report in order to present supplementary material. The first Appendix compares design parameters of the Deep Shaft Process relative to those of typical conventional activated sludge and extended aeration processes. The other two appendices contain miscellaneous observations and comments relating to the two phases of the study. In many cases, these are of a subjective nature and for this reason are excluded from the main text.

A specific exclusion in the whole study is data or comments relating to capital cost of the Deep Shaft Process. Capital cost of the Deep Shaft Facility at Paris is considered proprietory to CIL who paid all the costs of construction. The facility has also undergone extensive design changes since initial construction. Because the Paris facility is also a prototype, there is no published data base to establish capital cost of the process.

2.0 HISTORY

In June, 1975, J.D. Lee Engineering Ltd., on behalf of CIL, approached the MOE with the idea of demonstrating and experimenting with a system entitled "CIL Deep Shaft Process". The proposal was for CIL to build, own and operate a prototype demonstration facility on the site of the Paris WPCP. The facility could also be used to develop the data needed to obtain formal process approval from the MOE. Flow to the plant would be a split of the flow being pumped to the Paris WPCP aeration basins (note Figure 1). Approval was given by the MOE, who own the Paris WPCP, for CIL to build and demonstrate their plant. Flow was first received by the CIL plant on June 30, 1976. It was intended that when CIL had debugged the system the Wastewater Treatment Section would carry out an evaluation for MOE as part of the procedure for obtaining formal process approval. Such approval would allow the CIL process to be used to treat municipal sewage at other locations in Ontario.

Numerous mechanical and process problems were encountered and CIL did not sample intensively until January, 1977. Subsequent spot sampling and process alterations by CIL continued into March, 1977 when a meeting between CIL and MOE personnel was held. At that time, CIL, through their subsidiary Eco Research Ltd., withdrew their request for a design approval evaluation since they considered that performance of the deep shaft process at Paris was untypically poor. The Company felt that the poor process performance was due to the raw sewage characteristics at Paris. The Company also submitted data on probable effluent quality for consideration by the MOE.

Subsequently, on May 9, 1977, the MOE West Central Regional Office stated that they could not recommend that the deep shaft installation be purchased as the Paris WPCP expansion due to the expected poor quality of effluent. After consultation with the West Central Region and CIL, the WWT Section decided to conduct a limited evaluation to develop process information for the MOE. At the request of CIL, the evaluation was carried out at a constant flow rate of 5.25 l/sec. The study was subsequently carried out in two phases. Phase I (May 9 to May 27) covered a period when raw sewage influent to the Paris WPCP was of typical quality. At this time, the deep shaft system was sampled, design details were obtained and the operating procedures used by CIL were determined. Similar information was obtained about the Paris WPCP to determine if it could be used as a "control" during a detailed evaluation of the deep shaft system. Phase II of the study (July 18 to August 1) covered a period when the major industry discharging to the sewer system, a textile plant, was shut down for summer vacation. At this time, primarily domestic sewage was treated.

The objectives of the study are given in the next section.

3.0 OBJECTIVES

1. To determine, by a preliminary study, if a detailed evaluation of the CIL Deep Shaft Process can be justified at Paris. The preliminary study would include determining treatment efficiency, stage of process development and various parameters affecting the operating costs of treatment.

2. Through direct observation and sampling of plant performance, to develop and report information on a novel wastewater treatment process for the MOE. "In-house" knowledge, gained from direct observation, could be used to answer questions from the public, and to assist MOE staff in evaluating proposals for new installations.

4.0 CIL DEEP SHAFT PROCESS

The deep shaft plant at Paris receives sewage that has been through the coarse bar screen, grit chamber, comminutor and raw sewage pump of the Paris WPCP. Also, $FeCl_3$ has been added at 30 mg/l for phosphorus removal (note Figure 1).

The Paris WPCP raw sewage pump discharges to a splitter box where a portion of the flow goes to the Paris WPCP aeration basins and a portion goes to the CIL deep shaft plant which is enclosed in a heated 40'x40' building. The deep shaft portion is pumped by an airlift to a small feed tank which provides 2 to 3 minutes retention. Outflow from the tank is controlled by manual adjustment of a valve. Flows sent to the tank in excess of the amount needed by the shaft, bypass the CIL process and are returned to the Paris WPCP aeration tank. The overall result during the study was that a constant, smoothed flow entered the Deep Shaft Process. The tank was also used as the location for acid neutralization during Phase I of the study. A continuous pH monitor in the tank sends a signal to a sulphuric acid feed system so that pH is maintained around 7. Neutralized flow then passes through a trough where return sludge is added. This mixture is then put into the deep shaft for aeration. Neutralization and flow smoothing were installed after CIL had gained some experience at Paris. They had encountered problems with influent pH fluctuations and the raw sewage pumping schedule.

Figure 2 is a vertical profile of the shaft. The shaft head works includes the equipment illustrated in Figures 3 and 4. The figures do not show the foam tank or the two 1 HP foam breakers which are located

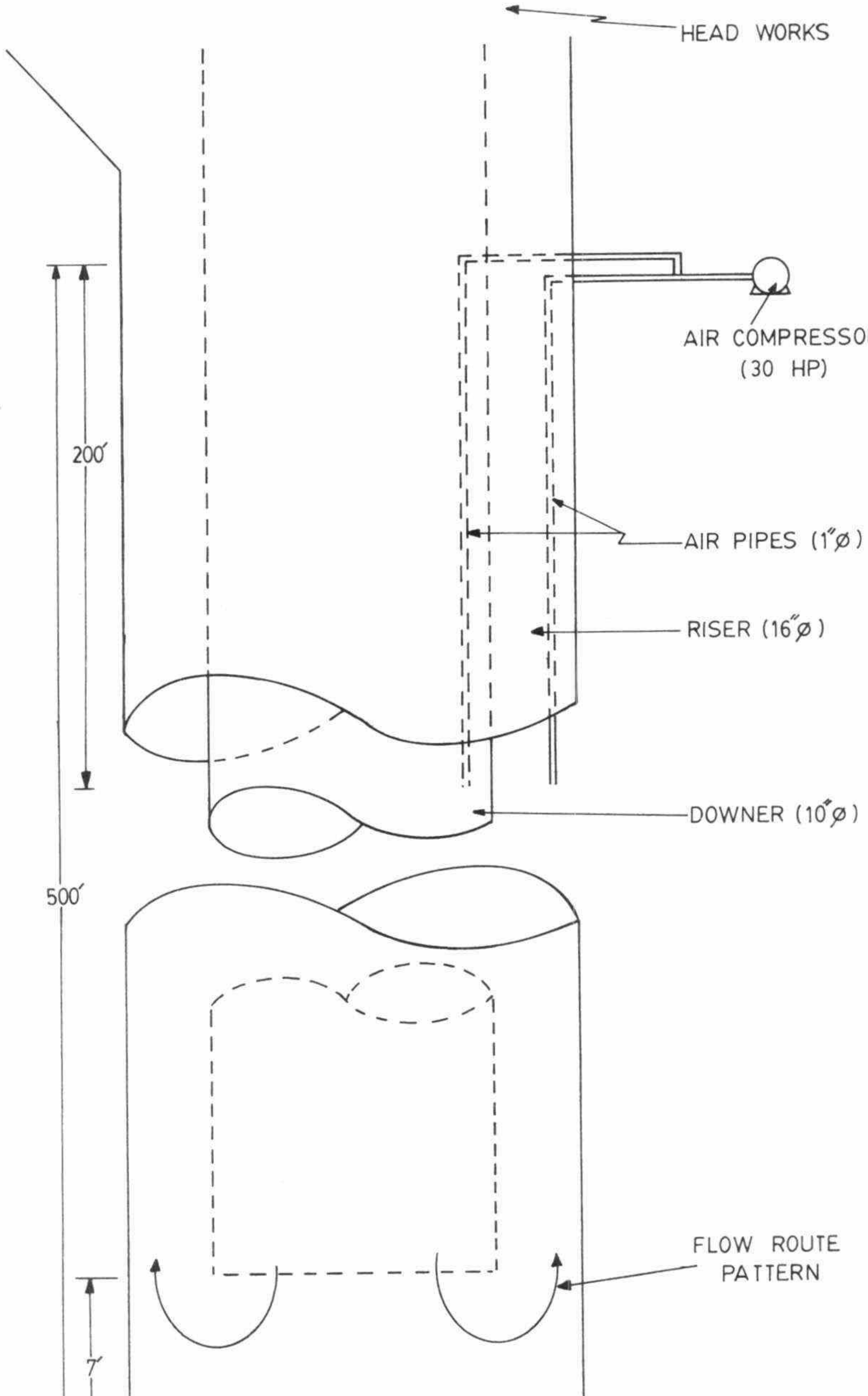


FIGURE: 2 PROFILE OF SHAFT PORTION OF DEEP SHAFT PROCESS

FIGURE:3 PLAN VIEW OF DEEP SHAFT HEAD WORKS

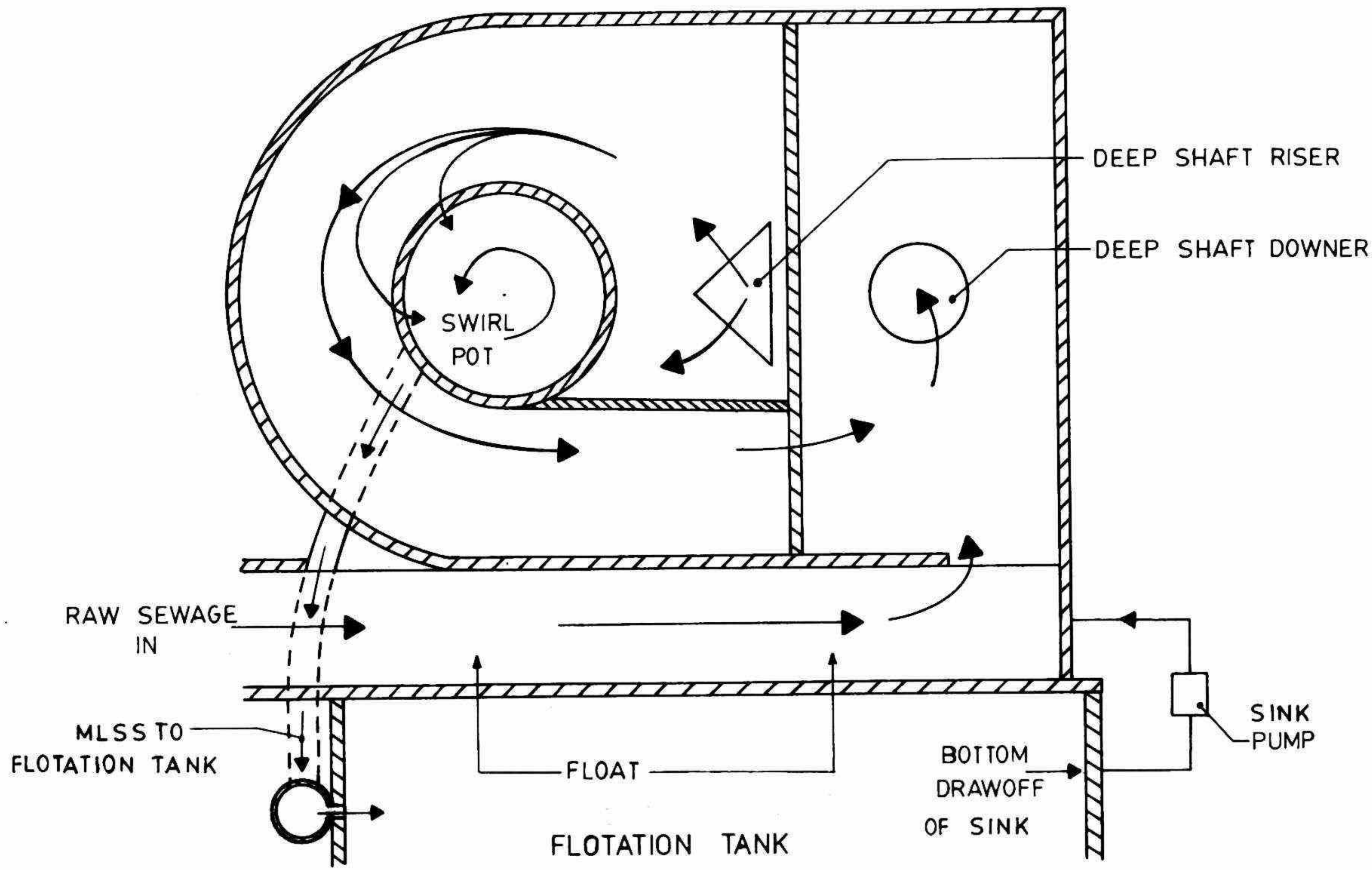
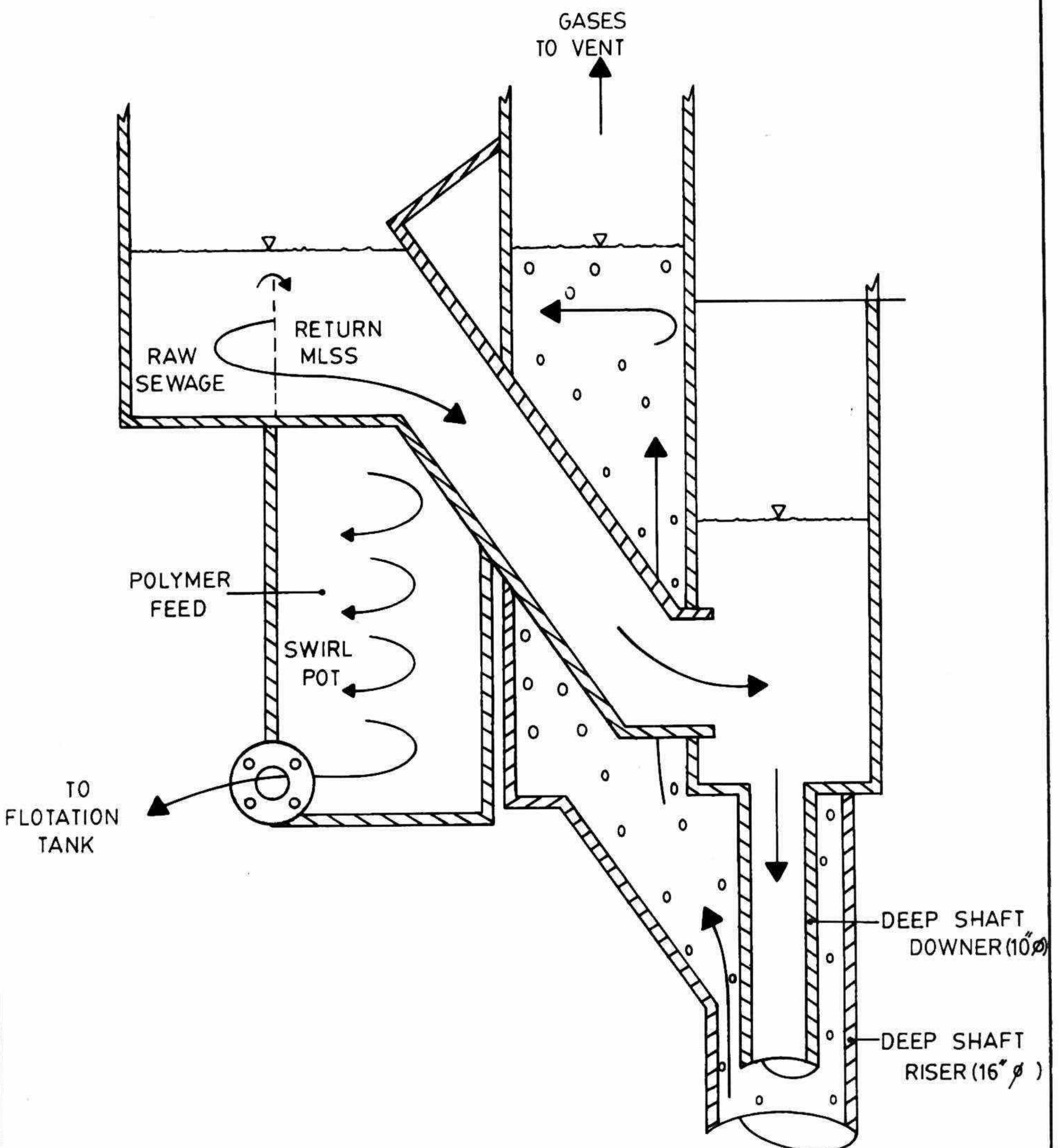


FIGURE:4 ELEVATION OF DEEP SHAFT HEAD WORKS



at the top of the head works. The deep shaft itself is a 40.6 cm (16 inch) diameter pipe which extends 152 meters (500 feet) into the ground. Inside of this is a 25.4 cm (10 inch) diameter pipe which extends almost to the bottom of the outside pipe. Air is supplied to the shaft through two 2.5 cm (1 inch) diameter pipes from an oversized 30 HP rotary screw type air compressor (a 15 HP compressor could possibly have been used). One air pipe is inside the 25.4 cm (10 inch) deep shaft pipe and one is in the 40.6 cm (16 inch) deep shaft pipe. Each air pipe goes down two hundred feet.

To start operation, the shaft is filled and air introduced to the outside pipe (riser). This results in an air-lift pumping action and starts liquid movement upwards in the riser and downwards in the centre pipe (down comer). With flow established through the shaft, air is injected into the down comer. Liquid motion draws the bubbles down the shaft where increase of hydrostatic pressure reportedly increases dissolved oxygen content in the liquid and enhances oxygen penetration into the biomass. As the liquid goes up the riser, the air again forms bubbles due to a decrease of hydrostatic pressure. These bubbles then contribute to the air-lift pumping action of the air injected into the riser. The rate of air injection is then adjusted in both the riser and the down comer until the air flow rate is at the minimum required to maintain flow through the shaft. Ideally, CIL would like to inject air only into the down comer. At Paris, CIL injects 935 l/m (33 cfm) into the down comer and 310 to 480 l/m (11 to 17 cfm) into the riser. The riser air helps to stabilize sewage circulation in the shaft. A portion of the

riser flow is split off through a swirl box as an overflow, and the remainder is recycled to the down comer (note Figures 3 and 4). Wasting of activated sludge is achieved by a 5 HP pump which pumps mixed liquor into the final effluent for about one hour a day. This wasting method relies on the Paris WPCP for sludge handling. CIL have stated that flotation tank float sludge could be wasted instead, but appropriate means were not installed at Paris.

Shaft effluent is mixed with a polymer (2 to 12 mg/l) in the overflow swirl pot (Figure 4) and discharged to the flotation unit. Polymer mixing and pumping requires a total of 1 3/4 HP. Flotation is achieved, without effluent recycle or supplementary air addition, by using only the air entrained in the MLSS. The flotation unit has surface dimensions of 7.6 meters (25 feet) long by 1.8 meters (6 feet) wide and is 1.8 meters (6 feet) deep. Float and sink are both returned to the shaft. Float is scraped directly into the shaft inlet launder while sink is scraped into a wet well. The sink is then pumped to the shaft. Each scraper has a 1 HP motor while the sink pump is air driven by the aeration compressor. Power usage is equivalent to about 2 HP.

Sampling is carried out by two automatic, sequential, refrigerated Sirco samplers. Effluent samples are taken from the discharge end of the flotation tank. The influent sample is taken after the equalization tank. Flow rates are measured after the flotation tank by a Parshall flume and a sonic level indicator and are continuously recorded on a strip chart. CIL also monitor changes in the oxygen content of the shaft off-gases as a means

of indicating when high organic loadings are occurring and therefore exerting a higher oxygen demand. No provision was made in the plant monitoring system to obtain representative composite mixed liquor samples or flow rates.

The shaft and flotation tank were designed for a 10.5 l/sec (0.2 IMGD) flow rate but during this study were always run at 5.25 l/sec (0.1 IMGD) due to undercapacity of the flotation tank. All data in the following report refer to the 5.25 l/sec flow rate. Shaft volume is about 16,000 litres (3,500 gallons) for a retention time of 50 minutes. The volume of the flotation tank is 25,500 litres (5,600 gallons) for a retention time of 80 minutes.

The unique features of the process are aeration in a 500 foot long shaft and solids separation by flotation without supplementary air addition. In addition, sludge wasting is by discharge of unthickened mixed liquor suspended solids.

As mentioned previously, a comparison of the CIL Deep Shaft Process description and performance was made with typical conventional activated sludge and extended aeration treatment plants and is presented in Appendix 11.1.

5.0 PHASE I OF THE PRELIMINARY STUDY

5.1 Paris Water Pollution Control Plant

The Paris WPCP is an extended aeration plant designed to treat 26.3 l/sec (0.5 IMGD) of mixed industrial/domestic sewage before discharge to the Grand River. The process schematic is shown in Figure 1. Influent quality, as determined by CIL, between July 28, 1976 and April 30, 1977 is presented in Table 1. This provides an indication of the treatment plant influent quality immediately prior to the study.

As noted in the previous section, raw sewage first passes through a coarse bar screen and then one of two grit channels. The screen and channels are manually cleaned when judged necessary by the operator. The sewage then passes through a comminutor and goes into a raw sewage wet well. Here, ferric chloride is added at a concentration of 30 mg/l for phosphorus removal. The sewage is then pumped to a splitter box which sends a portion of the flow to the CIL plant. The balance of the influent and the deep shaft effluent flow into surface aeration basins of the Paris WPCP. Following aeration, mixed liquors are clarified and chlorinated before discharge to the Grand River. Secondary sludge is returned to the aeration tank and clarifier skimmings are returned to the raw sewage wet well. No sludge is wasted from this plant.

The Wastewater Treatment Section studied the Paris WPCP (May 9 to May 27) in order to determine if results from the plant could be used as a control for the Deep Shaft Process. As a result, staff reviewed plant

Table 1

INFLUENT ANALYSES RESULTS BY CIL
FROM JULY 28, 1976 TO APRIL 30, 1977

	SS mg/l	BOD_5 mg/l	Soluble BOD mg/l	pH
Average	207	156	67.4	
Maximum	2,279	565	282	9.4
Minimum	28	15	7	6.8
No. of Samples	382	341	138	59

design, plant records and current operating procedures. In addition, some samples and flow measurements were taken and treatment efficiency was determined. The information gathered is being presented separately since it is not relevant to the study of the CIL Deep Shaft. However, some conclusions relating to the CIL study are included later in this report.

5.2 CIL Deep Shaft Process

During the period of May 9 to May 27, the Wastewater Treatment Section carried out the Phase I preliminary evaluation of the CIL Deep Shaft. The first week was taken up in familiarization with the plant and in learning the details of how the equipment is operated. The remaining time was used for sampling and observation.

The plant description has been given in Section 4 entitled "CIL DEEP SHAFT PROCESS".

The Paris WPCP raw sewage pump discharges to a splitter box where grab samples were taken of the flow to the CIL plant and the WPCP. As indicated in Table 2, the sewage quality leaving the splitter box was essentially the same to both plants. However, sludge and effluent from the CIL process were then added to the flow split going to the Paris WPCP aeration tank. Hence, the sewage quality entering the CIL plant differed from that entering the Paris aeration basins.

CIL influent and effluent were sampled by Sirco sequential samplers, set up to take a 500 ml sample for every 18 cubic meters (4,000 gallons) of flow through the shaft. Sequential samples were then hand composited into two 12-hour composite samples and a 24-hour composite. CIL and WWT then

TABLE 2

INFLUENT SAMPLES AND EVALUATION OF SPLITTER BOX EFFECT ON INFLUENT QUALITY TO EACH PLANT

Date	Time	BOD_5		S.S.	
		To CIL mg/l	To WPCP mg/l	TO CIL mg/l	To WPCP mg/l
May 16	2:30 pm*	278	281	367	363
	3:20 pm*	315	313	305	317
	3:50 pm*	278	278	365	347
	4:20 pm*	240	250	476	434
May 17	8 am - 4 pm	145	144	212	214
May 18	2:45 pm*		129		366
	8 am - 4 pm	186	148	213	268
May 19	8 am - 4 pm	143	134	217	229
May 20	8 am - 4 pm	127	128	238	208
May 24	9 am - 4 pm	158	166	281	268
May 25	8 am - 3 pm	137	113	165	155
May 26	8 am - 3 pm	145	122	200	205
Average		196	184	276	281

*Grab samples whereas all others are composites

each took a portion of the composite samples for analysis. The WWT samples were analyzed by the WWT laboratory and the MOE central laboratory. The 24-hour composite results are given in Table 3 while the 12-hour composite results are given in Table 4.

The influent samples were obtained between the acid addition (neutralization) point and the mixing point of sewage and flotation tank (return) sludge. As a result, all samples had a pH around 7. Effluent samples were taken from the discharge end of the flotation tank prior to overflow into the effluent channel.

The 24-hour composite averages (Table 3) of BOD_5 and SS indicate an effluent which is unacceptable to the MOE. The average BOD_5 is 67% higher and the average SS is 124% higher than the MOE effluent guidelines. The data (Tables 3 and 4) also indicate that large fluctuations occur in effluent quality. The MOE observer noted that solids being carried over into the effluent were generally large, flocculant and easily broken up. This also indicates that the flotation unit design or operation is the cause of the excessive solids loss. Also, for an effluent of this type, it is considered that soluble BOD_5 should be less than 10 mg/l for total BOD_5 to meet the MOE guidelines. Of the twelve 24-hour composite effluent samples (Table 3), only 3 (25%) were under 10 mg/l. However, since 9 (75%) were under 15 mg/l, there is still some prospect that the process may meet Ministry guidelines with further development or with improved operation.

The colour of the influent was very distinct and variable. Dark blues, reds, blacks and greens predominated. Occasionally, yellow, purple and light grey or green was observed. The darker colours were quite distinct

TABLE 3

TWENTY-FOUR HOUR COMPOSITE SAMPLES OF CIL DEEP SHAFT INFLUENT* AND EFFLUENT FOR FIRST PHASE OF STUDY

Date	BOD_5 mg/l			Suspended Solids mg/l			COD mg/l		
	INFL.	EFFL.	% REMOVAL	INFL.	EFFL.	% REMOVAL	INFL.	EFFL.	% REMOVAL
May 10	104	22	79	208	22	89	546	41	92
May 11	116	33	72	176	40	77	408	162	60
May 12	160	35	78	246	45	82	667	190	72
May 13	146	50	66	206	80	61	534	245	54
May 14/15	104	9	91	180	7	96	277	-	-
May 17	170	26	85	297	30	90	583	42	93
May 18	155	30	81	195	28	86	329	44	87
May 19	125	20	84	-	-	-	279	89	68
May 20	145	20	86	-	-	-	363	144	60
May 24	80	7	91	241	8	97	-	-	-
May 25	138	20	86	205	36	82	611	-	-
May 26	127			253	-	-	661	-	-
May 27	146	24	84	206	44	79	628	244	61
Average	132	25	81	219	34	84	490	133	73
MOE guideline		15			15				

* after screening, grit removal, comminution, addition of ferric chloride, neutralization and equalization

TABLE 3 (cont.)

Date	SOLUBLE BOD_5 mg/l			KJELDAHL NITROGEN mg/l			TOTAL PHOSPHORUS mg/l		
	INFL.	EFFL.	% REMOVAL	INFL.	EFFL.	% REMOVAL	INFL.	EFFL.	% REMOVAL
May 10	53	11	79	28	17	39	5.0	0.34	93
May 11	54	19	65	29	19	34	5.8	1.3	78
May 12	79	19	76	56	17	70	9.9	1.2	88
May 13	50	22	56	28	21	25	5.5	2.3	58
May 14/15	21	9	57	29	19	34	5.4	0.64	88
May 17	73	14	81	33	16	52	5.8	0.55	91
May 18	81	12	85	26	13	50	4.9	0.42	91
May 19	52	8	85	30	15	50	6.6	0.75	89
May 20	63	11	83	29	13	55	8.2	0.8	90
May 24	13	6	54	27	16	41	5.0	0.24	95
May 25	71	10	86	28	14	50	4.8	0.96	80
May 26	77	-	-	54	-	-	8.8	-	-
May 27	46	12	74	34	17	50	8.6	1.1	87
Average	56	13	77	33	16	52	6.5	.88	86
MOE guideline								1.0	

TABLE 4

COMPARISON OF PHASE I DAY AND NIGHT TIME 12-HOUR COMPOSITE SAMPLES OF CIL INFLUENT & EFFLUENT

	INFLUENT				EFFLUENT			
Date	BOD_5 mg/l		Suspended Solids mg/l		BOD_5 mg/l		Suspended Solids mg/l	
	9 pm* - 9 am	9 am - 9 pm	9 pm* - 9 am	9 am - 9 pm	9 pm* - 9 am	9 am - 9 pm	9 pm* - 9 am	9 am - 9 pm
May 10	86	180	150	243	19	22	18	22
May 11	134	154	142	184	46	21	52	32
May 12	133	220	202	248	33	34	43	48
May 13	138	158	174	480	54	52	95	63
May 14/15	103	140	188	244	18	22	12	31
May 17	123	240	115	412	31	41	41	28
May 18	166	144	157	232	35	25	30	18
May 19	90	159	-	-	20	25	-	-
May 20	143	128	-	-	21	17	-	-
May 24	78	95	178	206	6	7	9	10
May 25	74	190	147	296	30	25	43	26
May 26	105	140	167	346	-	-	-	-
May 27	106	190	174	199	26	19	60	19
Average	114	164	163	281	28	26	40	30

* PM refers to 9PM of previous day given in date column

and the influent would change colour quite rapidly. The effluent would also be coloured but not as strongly as the influent. The influent very seldom looked like typical sewage.

The influent COD results for Phase I have a range of 277 mg/l to 667 mg/l. During weekdays, most influent COD readings were over 500 mg/l, indicative of considerable industrial waste input. The expected removal efficiency from a conventional plant is from 70% to 85%. The average COD removal of 73% by the CIL Deep Shaft is already within the lower end of the range but could be improved if operational and process changes resulted in increased SS and BOD_5 removals. Such improvements might result from continuous supervision, higher polymer dosage and/or an improved clarification process.

Influent and effluent Kjeldahl nitrogens are typical values for conventional non-nitrifying sewage treatment plants. Total phosphorus values and removals are also typical with the effluent average value of 0.88 mg/l meeting the MOE objective.

The 12-hour composite samples were taken to see if there is a difference between the results from daytime and nighttime. A comparison of BOD_5 and SS is given in Table 4. This indicates that the influent analyses show a difference, as expected, due to lower domestic and industrial loadings at night. The effluent samples do not show the same trend. The average effluent values of BOD_5 for daytime and nighttime are close, with an equal number of occasions on which the higher 12-hour value occurs during the daytime or nighttime period.

The average value of effluent suspended solids is higher at nighttime. The higher of the two 12-hour values occurs almost as often during daytime as nighttime.

The variations are not easy to explain but might be due to the deep shaft process having a lower treatment efficiency with lower strength wastes or the lack of operator attention during the night. Sampling and investigation was insufficient to determine whether one of these reasons is correct or if there is some other explanation.

Table 5 compares the deep shaft effluent data from all composite samples, based on the number of analyses less than the MOE objectives, those between 15 and 30 mg/l and those over 30 mg/l for BOD_5 and SS. The phosphorus data are split between less than or greater than 1.0 mg/l, since 1.0 mg/l is the general MOE guideline. Only 9 of 66 (14%) analyses for BOD_5 and SS were within MOE guidelines. Of these, four were BOD_5 analyses and five were SS analyses. About 40% of the analyses were over twice the MOE guidelines of which fifteen were for SS and eleven were for BOD_5. For total phosphorus, 67% of the analyses were below the MOE objective. On four occasions, the MOE objective was exceeded but there was only one analysis which was substantially above the objective. The processes contributing to phosphorus removal included ferric chloride addition, polymer addition and biological uptake. The actual mechanism of phosphorus removal was not investigated. Losses are assumed to have been associated with solids losses to the effluent.

Gradual deterioration of effluent quality can be noted between May 10 to May 13, during the industrial working week. For example, in Table 4, the effluent SS quality deteriorated from 18 mg/l to 95 mg/l.

TABLE 5

COMPARISON OF THE NUMBER OF TIMES THE CIL
DEEP SHAFT PROCESS EFFLUENT MEETS OR EXCEEDS MOE
GUIDELINES DURING PHASE I

Parameter	Range mg/l	Number of Analyses 9 am - 9 pm	9 pm - 9 am	24 hour
S.S.	< 15 mg/l	1	2	2
	15 - 30 mg/l	5	2	3
	> 30 mg/l	4	6	5
BOD	< 15 mg/l	1	1	2
	15 - 30 mg/l	8	6	7
	> 30 mg/l	3	5	3
Total P	≤ 1.0			8
	> 1.0			4

Although not as distinct, a similar trend occurred after the next weekend (May 14 and 15). There was some recovery over the weekend when the textile plant was not in operation.

Grab samples of the deep shaft mixed liquor were analyzed and the results are presented in Table 6. Results indicate that the mixed liquor suspended solids are quite variable. For example, on May 24, the results showed that 3,000 mg/l MLSS was lost from the shaft between morning and afternoon. This could have been due to sludge wasting, solids sinking in the flotation tank and therefore not being returned to the shaft quickly enough and/or solids being lost to the effluent. Whatever the cause, the variations illustrate a poor control of MLSS.

Volatile solids levels (Table 6) in the mixed liquor are over 80% of the suspended solids figure. This is a high figure relative to conventional treatment, but might be expected for a high rate plant.

Other comments and observations which resulted from the Phase I preliminary evaluation of the CIL Deep Shaft Process are presented in Appendix 11.2.

5.3 Conclusions and Recommendations

The major conclusions reached were that the CIL Deep Shaft Process did not produce a consistent effluent at Paris and the effluent was not meeting the MOE guidelines. Contributory factors may have included the process being in an early stage of development, the lack of full-time operator attention, the use of a flotation unit for secondary clarification, and/or the presence of interfering industrial wastes. There was no ready means of distinguishing between these factors at Paris.

TABLE 6

MIXED LIQUOR SAMPLES FROM CIL DEEP SHAFT DURING PHASE I

Date	Time	Parameter (mg/l)		
		S.S.	V.S.S.	% VOLATILE
May 19	morning	5,270	4,290	81.4
May 19	afternoon	4,520	3,700	81.4
May 20	morning	5,560	4,620	83.1
May 24	morning	8,250	6,510	78.9
May 24	afternoon	5,270	4,340	82.4
May 25	morning	8,650	7,160	82.8
May 25	afternoon	9,420	7,780	82.6
May 26	morning	3,750	2,960	78.9
May 26	afternoon	4,270	-	-

As a result of the Phase I study, it was decided that an extended and detailed study would not be justified at the Paris site. Since the process showed some potential, it was decided to carry out another preliminary study of the deep shaft process when treating sewage without the textile wastes. This would be possible between July 15 and August 1 when the textile plant was closed for summer vacations. During this time, the sewage would still contain some industrial wastes but would much more closely approach domestic sewage.

The investigation of the Paris WPCP determined that it was not meeting MOE objectives either. Contributory factors may have included:

- possible adverse effects of industrial wastes on the biological process.
- impact of the deep shaft process on the Paris WPCP through shock organic loadings from sludge wasting.
- non-standard operating practices at the WPCP.

As a result of the above, it was concluded that the Paris WPCP was not a suitable control for evaluating the deep shaft process.

6.0 PHASE II OF THE PRELIMINARY STUDY OF THE CIL DEEP SHAFT PROCESS

Based on the Phase I conclusions, a second preliminary study of the CIL Deep Shaft was carried out from July 15 to August 1. CIL again operated the plant while WWT observed the operation and took samples for analysis by the MOE Laboratories. The objective was to get an indication of the treatment efficiency of the CIL process while treating basically domestic sewage.

No analyses were conducted on the Paris WPCP effluent or MLSS during this period because of the much reduced total sewage flow and hence greater potential impact of the CIL process upon the WPCP. Additionally, major maintenance was being done to the WPCP aeration basins. This resulted in a significant disruption of the plant and atypical operation and effluent quality.

Due to the short period that the textile plant was to be shut down, CIL decided to obtain biomass adapted to domestic sewage in order to minimize acclimation time of the deep shaft process. Therefore, in the week of July 10, influent to the CIL plant was shut off and the flotation tank, equalization tank and deep shaft head works were emptied and all sludge accumulations cleaned out. After the textile plant had closed, influent was allowed to enter the process until the deep shaft was completely filled and the flotation unit partly filled. Shaft air was started and shaft circulation established. Activated sludge was obtained from a water pollution control plant treating domestic sewage and was mixed with the influent. This was done on Saturday, July 16.

During Phase II, constant flow was again maintained but there was no neutralization. During the first week of Phase II (July 17-23) flow varied from 6 to 7.8 l/sec (114,000 gpd to 149,000 gpd), polymer dosage (Praestol 423K) from 5 to 10 mg/l. Sludge wasting occurred for one hour a day and air flows were 480 l/m (17 cfm) to the riser and 934 l/m (33 cfm) to the downer. Changes to process operation started on Sunday, July 24, when sludge wasting was changed to two minutes every hour, instead of one hour per day. On Tuesday, July 25, further process changes included increased submersion of the top rakes in the flotation cell. This resulted in a deeper cross-section of float being sent to the shaft and possibly a lowering of the food to microorganism (F/M) ratio in the shaft. Sludge wasting was discontinued for the day and polymer addition was increased to 7.5 mg/l and later to 10 mg/l. These increases were sustained for extended periods. Other changes in polymer addition rate were made daily by the operators as thought required. An approximate operating cost for polymer is presented in Appendix 11.2 as comment no. 7.

At noon hour on July 27, CIL personnel started to monitor and control the plant on a 24-hour basis whereas previously, plant operators were generally on-site only from 8 a.m. to 5:30 p.m. This was continued until August 1 at noon hour. The switch to 24-hour surveillance took place because the plant was reportedly experiencing an upset between 1 and 4 a.m.

During the five days of continuous surveillance, changes were made to polymer dosage, air supply, rake speed, water level in the flotation tank and sludge return rate. In addition, on July 31, August 1 and August 2, CIL dosed the influent to the shaft with alum. Initially,

18 kgms (40 lbs) of alum were added and it was planned that 2.27 kgms (5 lbs) would be added in a slug every 6 hours for 48 hours. This would have been equivalent to an average feed rate of 0.38 kgms/hr. CIL actually fed alum at rates between 0.19 kgms/hr and 5.5 kgms/hr. Also, instead of dosing for 48 hours, alum was added for 64 hours. These figures illustrate the random way that operational changes were made by CIL throughout the two phases of the study. The polymer feed was also frequently changed between 2 mg/l and 10 mg/l during this period. CIL stated that alum was "not effective and that the higher values of polymer concentration are required for solids removal". The latter was generally observed to be true at all times to maintain good solids removals although the optimum dosage was not determined.

Influent and effluent sample locations and types during Phase II were the same as for Phase I. As in Phase I, MLSS analyses were done on grab samples taken from the piping between the swirl pot and the flotation tank. Analyses of flotation tank float and sink were also done on grab samples. The float samples were obtained from the flotation tank beach just prior to where the float was mixed with the raw sewage. Sink samples were taken from the discharge of the sink pump.

Influent and effluent results are given in Tables 7, 8 and 9. The average daily removal efficiencies of BOD_5 and SS in Phase II without textile wastes are 72% and 77% while the respective average effluent concentrations are 38 mg/l and 53 mg/l. Therefore, the effluent quality, while treating basically domestic sewage, again did not meet the effluent require-

TABLE 7

TWENTY-FOUR HOUR COMPOSITE SAMPLES OF CIL DEEP SHAFT INFLUENT*
AND EFFLUENT FOR PHASE II OF THE
PRELIMINARY STUDY

Date	BOD_5 mg/l			SOLUBLE BOD_5 mg/l			SUSPENDED SOLIDS mg/l		
	INFL.	EFFL.	% REMOVAL	INFL.	EFFL.	% REMOVAL	INFL.	EFFL.	% REMOVAL
July 18	214	-	-	48	-	-	349	41	88
July 19	181	-	-	36	-	-	214	12	94
July 20	149	62	58	26	4	85	224	44	80
July 21	161	82	49	26	7	73	332	77	77
July 22	120	15	88	30	3	90	254	75	70
July 23	98	69	30	25	4	84	156	150	4
July 24	-	16	-	-	3	-	-	95	-
July 25	148	91	39	33	8	76	217	90	59
July 26	133	11	92	24	5	79	184	15	92
July 27	141	37	74	36	9	75	250	24	90
July 28	150	15	90	29	3	90	184	17	91
July 29	122	7	94	31	3	90	249	11	96
July 30	143	10	93	67	4	94	234	10	96
July 31	110	8	93	14	3	79	202	17	92
Aug. 1	154	69	55	22	9	59	224	122	46
Average	136	38	72	32	5	84	234	53	77
MOE Objective		15						15	

* Influent refers to sample taken after CIL's equalization

TABLE 7 (cont.)

Date	COD mg/l INFL.	COD mg/l EFFL.	COD % REMOVAL	KJELDAHL NITROGEN mg/l INFL.	KJELDAHL NITROGEN mg/l EFFL.	KJELDAHL NITROGEN % REMOVAL	TOTAL PHOSPHORUS mg/l INFL.	TOTAL PHOSPHORUS mg/l EFFL.	TOTAL PHOSPHORUS % REMOVAL
July 18	306	43	-	32	-	-	6.6	-	-
July 19	260	35	-	33	-	-	5.6	-	-
July 20	290	69	76	32	19	41	5.6	1.1	80
July 21	440	76	83	28	18	36	8.7	0.86	90
July 22	225	67	70	24	17	29	4.8	0.8	83
July 23	153	113	26	29	21	28	5.4	3.0	44
July 24	-	51	-	-	17	-	-	1.0	-
July 25	245	230	6	30	14	53	5.8	0.64	89
July 26	198	25	87	32	17	47	5.2	0.28	95
July 27	254	41	84	32	16	50	5.4	0.4	93
July 28	218	33	85	31	18	41	5.2	0.24	95
July 29	296	27	91	31	16	48	6.8	0.26	96
July 30	306	27	91	29	18	38	5.4	0.24	96
July 31	195	24	88	27	16	41	5.9	0.22	96
Aug. 1	227	140	38	29	21	28	6.3	3.1	51
Average	258	67	74	30	18	41	5.9	.9	84
MOE Objective								1.0	

TABLE 8

COMPARISON OF PHASE II DAY AND NIGHT TIME 12-HOUR COMPOSITE SAMPLES OF CIL INFLUENT AND EFFLUENT

Date	INFLUENT BOD$_5$		INFLUENT Suspended Solids		EFFLUENT BOD$_5$		EFFLUENT Suspended Solids	
	9 pm* - 9 am	9 am - 9 pm	9 pm* - 9 am	9 am - 9 pm	9 pm* - 9 am	9 am - 9 pm	9 pm* - 9 am	9 am - 9 pm
July 18	>800	135	1,437	177	23	36	-	-
July 19	175	165	197	221	20	29	-	-
July 20	120	170	193	255	78	49	64	23
July 21	93	363	125	436	98	66	108	40
July 22	84	127	214	219	24	13	127	99
July 23	93	103	155	165	61	15	311	170
July 24	-	-	-	-	16	22	26	109
July 25	90	195	136	300	22	33	37	26
July 26	87	179	145	215	48	133	12	16
July 27	92	180	123	246	21	44	21	20
July 28	120	180	127	203	9	25	9	24
July 29	148	121	277	173	5	105	8	16
July 30	111	136	238	244	10	6	9	8
July 31	85	126	186	193	8	6	10	10
Aug. 1	111	118	221	213	86	57	157	72
Average	108	164	180	236	35	44	69	44

* 9 pm is from the day preceeding the date shown in the left column and the July 18th analyses are not included in the averages for BOD$_5$ and S.S.

TABLE 9

COMPARISON OF THE NUMBER OF TIMES THE CIL DEEP
SHAFT PROCESSES EFFLUENT MEETS OR EXCEEDS MOE GUIDELINES
DURING PHASE II

Parameter	Range mg/l	Number of Analyses		
		9 am - 9 pm	9 pm - 9 am	24 hours
S.S.	< 15	2	5	3
	15 - 30	6	2	4
	> 30	5	6	8
BOD_5	< 15	3	4	4
	15 - 30	4	6	3
	> 30	8	5	6
Total P	≤ 1.0			9
	< 1.0			4

ments for discharge to the Grand River. The fluctuation in results of the 24-hour composites is relatively large, with the maximum values being 91 mg/l BOD_5 and 150 mg/l SS. It should be noted that July 29, 30 and 31 produced the best effluent quality with minimal fluctuation. This was during the time that CIL had an operator on duty for 24-hours per day. Continuous supervision is thought to be the reason for the improvement of effluent quality.

Of all effluent composite samples taken during Phase II, only 24% of the SS and 26% of the BOD_5 values met the MOE guidelines (Table 9). The BOD_5 and SS values which are over twice the objectives are 44% and 46% respectively of all sample results.

Phosphorus entering the CIL plant is within the range expected for domestic sewage. Of this, 84% is removed by the Deep Shaft process resulting in 9 of 13 samples being better than the MOE objective of 1.0 mg/l total phosphorus. On the two occasions that the effluent concentration was at, or above 3 mg/l, the solids removal efficiency was relatively poor. Therefore, improved solids control would probably ensure that MOE phosphorus objectives are not exceeded.

Also, all of the soluble BOD_5 analyses were under the 10 mg/l value, the significance of which was referred to in the discussion of Phase I. Therefore, if the solids removal was improved, the MOE BOD_5 limit would possibly be met. This is based on a coarse estimate of the relationship of soluble and total BOD_5.

The influent Kjeldahl nitrogen values determined during this phase of the Deep Shaft study were from 24 mg/l to 33 mg/l. Effluent Kjeldahl nitrogen values during the study were between 14 mg/l and 21 mg/l for an average removal efficiency of 41%. This removal efficiency is lower than the expected 50 to 60% removal from a conventional activated sludge plant. A high rate plant would be expected to have a removal efficiency of 20 to 30% for a municipal waste.

The August 1 results (Table 7) show the influence of the alum addition and indicate a significant deterioration of effluent quality.

Table 10 shows the results of the grab sampling of the mixed liquor, float and sink during Phase II. The samples were taken in an attempt to develop a solids balance through the process. Due to the variability of the solids levels and the lack of a reliable measuring and sampling system, a solids balance could not be developed. Therefore, it could not be determined if more or less sludge is produced by the deep shaft process than by a conventional activated sludge process. The data in Table 10 show the variability of solids levels in the mixed liquor and the sink, and also the high solids concentration of the float. The variability in MLSS shows a need for a more reliable and consistent operation. The high solids concentration in the float may be significant for WPCP's which require sludge thickening as a stage in further dewatering. The volatile portion of the MLSS is just over 70% and is approximately that of a conventional treatment plant. A higher value would be expected for a high rate plant.

Additional comments and observations are presented in Appendix 11.3.

TABLE 10

COMPARISON OF SLUDGE & MIXED LIQUOR GRAB SAMPLES DURING PHASE II

Date	Mixed Liquor		Sludge			
			Float		Sink	
	S.S. %	V.S.S. %	S.S. %	V.S.S. %	S.S. %	V.S.S. %
July 20	0.36	0.25	-	-	-	-
July 20	-	-	7.0	4.6	-	-
July 21	0.33	0.22	6.4	4.4	0.58	0.42
July 22	0.30	0.22	7.2	5.0	0.43	0.30
July 23	0.38	0.26	6.6	4.4	0.76	0.51
July 24	0.37	0.26	6.4	4.4	0.19	0.13
July 25	0.30	0.21	6.9	4.9	0.25	0.17
July 26	0.35	0.25	7.1	5.0	0.02	0.01
July 27	0.61	0.44	6.9	4.9	0.01	0.007
July 28	0.60	0.44	6.0	4.3	0.02	0.01
July 29	0.34	0.25	8.0	5.8	0.11	0.08
July 30	0.12	0.09	7.8	5.6	0.03	0.02
July 31	0.50	0.36	6.8	4.8	0.03	0.02
Aug. 1	0.39	0.28	5.0	3.5	0.11	0.08
Aug. 2	0.71	0.52	5.0	3.5	0.43	0.31
Mean	0.40	0.29	6.6	4.6	0.23	0.16
Range	0.12-0.71	0.09-0.44	5.0-8.0	3.5-5.8	0.01-0.76	0.007-0.51

7.0 COMPARISON OF PHASES I AND II

Comparison of analyses from the two phases for selected parameters (Table 11), shows that the influent quality was relatively similar with and without the textile wastes except for COD and soluble BOD_5. But while the effluent BOD_5 and SS quality deteriorated, soluble BOD_5 and COD improved in Phase II, without textile wastes. Effluent nutrient levels (TKN and Total-P) remained the same.

Influent colour during Phase II varied between light tans, greys and greens. Although some colours uncharacteristic of domestic sewage were present, they did not have the same intensity or vary as greatly as observed during Phase I. The absence of the textile plant discharge in Phase II is also shown by comparing the COD data of Tables 3 and 7. During Phase II, the influent COD was mostly between 200 mg/l and 300 mg/l. These values contrast with the Phase I COD's of 500 mg/l to 700 mg/l which are typical when the textile waste is in the influent.

COD removal efficiency remained the same for both phases. The lower effluent concentrations in Phase II are those that would be expected from a conventional plant when treating a domestic sewage. Soluble BOD_5 concentration dropped from the Phase I average effluent value of 13 mg/l to 5 mg/l in Phase II. The latter value indicates that there is potential to produce an effluent which would meet the MOE objectives if suspended solids removal was improved. The percentage of volatile suspended solids in the MLSS decreased from over 80% for Phase I to just over 70% in Phase II. This is associated with a lower MLSS value in Phase II. The reasons for the differences were not determined.

TABLE 11

COMPARISON OF AVERAGE SAMPLING RESULTS FOR PHASE I AND II FOR DEEP SHAFT PROCESS*

Parameter	With Textile Wastes			Without Textile Wastes		
	Inlet mg/l	Outlet mg/l	% Removal	Inlet mg/l	Outlet mg/l	% Removal
BOD_5	132	25	81	136	38	72
Soluble BOD_5	56	13	77	32	5	84
S.S.	219	34	84	234	53	77
COD	490	133	73	258	67	74
K-Nitrogen	33	16	52	30	18	41
Total Phosphorous	6.5	0.88	86	5.9	0.9	84

*Averages are the arithmetical mean of the 24 hour composite samples from Tables 3 and 8

Generally, CIL staff operated and monitored the plant in the same way for both phases. In both cases, numerous alterations were made to the polymer feed and in flotation tank operation. The major operating and process differences between Phase I and II were the discontinuation of neutralization and the three days of continuous operator attention during Phase II. Continuous operating supervision seemed to significantly improve effluent quality.

8.0 CONCLUSIONS

The following conclusions were reached as a result of Phases I and II:

1. While operating on the normal Town of Paris municipal wastewater during Phase I, the CIL Deep Shaft Process produced an effluent with average BOD and SS values of 25 and 34 mg/l. BOD and SS values ranged between 7 and 50 mg/l, and 7 and 80 mg/l, respectively.

2. During Phase II, while treating primarily Paris domestic wastewater, the CIL Deep Shaft Process produced an effluent with average BOD and SS values of 38 and 53 mg/l. Effluent values ranged between 7 and 91 mg/l and 10 and 150 mg/l for BOD and SS, respectively.

3. Based on the results of this study, more detailed evaluation of the CIL Deep Shaft Process by the MOE is not justified until CIL can demonstrate improved operating results.

4. Fluctuations in effluent quality, float quality and MLSS concentrations were quite large, frequent and significant. Control of fluctuations or process upsets were "after the fact".

5. The Deep Shaft Process at Paris required more intensive operator supervision than conventional biological processes of similar design capacity. The degree of supervision and the level of operator skills needed were not exactly determined.

6. *The operating costs of the Deep Shaft were relatively high when taking into account the cost of polymer, and total compressor energy. The equipment is housed in a building which results in some extra operating costs involving power consumption (e.g. for lighting and ventilation.*

9.0 RECOMMENDATIONS

The following recommendations are presented as a result of a preliminary evaluation of the Deep Shaft Process:

1. *That the Wastewater Treatment Section postpone any detailed evaluation of the CIL Deep Shaft Process until an acceptable and consistent effluent quality is obtained.*

2. *That CIL establish a consistent approach to their field research and consider:*
   - *less frequent process or equipment changes to allow the biological system to stabilize so that the effect of each change can be fully evaluated.*
   - *standardizing and scientifically justifying changes to process such as the amount of polymer added and liquid level in flotation tank.*

3. *That CIL consider a process change to permit the wasting of float solids rather than mixed liquor suspended solids.*

4. *That future studies include an estimation of the amount of supervision and/or instrumentation required to effectively control the complete process.*

10.0 ACKNOWLEDGEMENTS

Acknowledgement is made of the cooperation and assistance by Eco Research Ltd. staff, in particular Ken Chisholm, during this study. Also, acknowledgement of Wastewater Treatment Section staff involved is made for the on-site work of Cec Howes and Domenico Imineo and for the special attention to laboratory analyses by Vera Turner. Assistance during the complete study, and in particular during the investigation of the Paris WPCP, was given by Henry Nelles the chief operator and by Peter Postern of the MOE West Central Region.

11.0 APPENDICES

APPENDIX 11.1

DESIGN AND PERFORMANCE COMPARISON

OF CIL DEEP SHAFT PROCESS WITH

CONVENTIONAL ACTIVATED SLUDGE TREATMENT

AND EXTENDED AERATION TREATMENT

In this Appendix, the Phase II configuration of the CIL Process at Paris is compared with typical design loading and other operating parameters for conventional and extended aeration plants. Since effluent quality has already been extensively discussed in the main text, it will not be addressed in detail in this Appendix.

A reference to a flotation unit designed to clarify mixed liquor suspended solids was not located, so a comparison is made between the CIL flotation unit and the London, Ontario flotation units installed for sludge thickening. It so happened that the latter also produced a clarified effluent with low suspended solids (Table 12).

Necessary pre-treatment prior to the aeration section is considered similar for all treatments and includes screening, comminution, and grit removal. Conventional activated sludge is the only process typically making use of primary clarification. The Deep Shaft Process is the only one potentially needing a constant flow rate. The importance of the presence or absence of constant flow, with respect to the biological action in the shaft, was not evaluated. This was due to the shortness of the study and the developmental nature of the Paris deep shaft. However, the short detention and small liquid volume in the shaft probably necessitates a constant flow rate in situations where there are significant fluctuations of raw sewage quality or quantity. While shock loadings might result only in a sludge of poor quality effluent, they might also result in a complete upset of the flotation unit. This could in turn upset the shaft due to a low sludge return rate if there is no float. Conventional biological treatment plants, designed to approach "complete mix" in the aeration basin, have more built-in buffer capacity against shock loads due to longer detention times, and the larger and more accessible sludge inventory.

TABLE 12

COMPARISON OF CIL DEEP SHAFT DURING

PHASE II WITH CONVENTIONAL DESIGN PRACTICE

	CIL Deep Shaft at Paris	Conv. Activated Sludge	Extended Aeration
Primary Treatment			
Bar Screens	Yes	Yes	Yes
Grit Removal	Yes	Yes	Yes
Clarifier	No	Yes	No
Constant Flow Rate	Possibly	No	No
Aeration Tanks			
Retention (hrs)	0.8	4-6	19-24
F/M (Kgm BOD_5/Kgm MLVSS/day or lbs/lb)	1.3	0.2-0.4	0.1
Organic loading (Kgm BOD_5/cu m of aeration tank/day)	3.8	0.5-0.8	0.08-0.24
(lbs BOD_5/1000 cu ft)	240	30-50	5-15
Sludge Production (Kgm/Kgm BOD_5 removed or lbs/lb)	Not determined	0.6-0.8	0.15-0.4
SRT (days)	Not determined	2-5	15
Air Supplied (cu m/Kgm BOD_5 removed)	45.9	93.6	125
(cu ft/lb BOD_5 removed)	735	1500	2000
HP (100,000 gpd, 98 mg/l BOD removed)	15	3.25	4.35
Hydraulic Gradient (ft)*	5.5	5.5	4.0

Table 12 (cont'd)

Flotation Tank	CIL Deep Shaft	London*** Sludge Thickening
Polymer Concentration		
mg/l	8-10	18
Kgm/metric ton SS to flotation tank ***	2.3	3.0
lbs/ton SS to flotation tank	4.5	5.9
Hydraulic Loading		
Influent lpm/m^2	22.5	18.1
gpm/ft^2	0.46	0.37
Influent + Recycle lpm/m^2	-	116
gpm/ft^2	-	2.37
Detention min. (recycle excluded)	80	140
Solids Loading $Kgm/m^2/hr$ ****	5.4	12.7
$lbs/ft^2/hr$	1.1	2.6
SS Concentrations		
Influent mg/l	4,000	12,000
Effluent mg/l	53	25
Float %	6.6	3.7
Effluent Recycle	No	No
Air Addition		
Kgm air/Kgm dry solids at 80 psig or 5.6 Kgm/cm^2 or (lb air/lb solids)		
HP credit**	20	-

Table 12 (cont'd)

* *Gradient for Deep Shaft Process is difference between maximum water level in constant flow regulator and the bottom of the flotation tank discharge channel. For conventional activated sludge, gradient is between maximum water level in primary clarifier to bottom of secondary clarifier effluent channel. The extended aeration plant gradient is the difference between the maximum water level in the aeration basin and the bottom of the secondary clarifier effluent channel. The hydraulic gradient for pretreatment, flow measuring and chlorination would be the same for each plant and is not included in the figures.*

** *This is HP not required by CIL flotation unit because a portion of the effluent is not pressurized and recycled to supply air bubbles to the unit. Value includes air compressor and water pump.*

*** *Personal communication from J. Choma of the City of London.*

**** *It is emphasized that SS loading is based on MLSS loading sent to tank rather than the SS loading of the float.*

The aeration tank data (Table 12) illustrates that the shaft has a lower detention time and higher loading rate than either conventional or extended aeration treatment. Unfortunately, sludge production and SRT cannot be compared since CIL has not installed appropriate sampling equipment or used good procedures to permit their accurate estimation. A potential advantage of the Deep Shaft Process is the substantially lower air requirement. This advantage though is counteracted by the estimated 15 HP (30 HP installed) needed to supply 50 scfm of air at 105 psi. Effective horsepower at Paris was possibly over three times that which would be required by extended aeration.

Estimates of hydraulic gradients through the aeration section of the plants are also given in Table 12. These show that, as built in Paris, the Deep Shaft Process has a gradient equivalent to that for a conventional activated sludge plant. For the Deep Shaft, 1.2 meters of head is required by the constant flow regulator and 0.5 meters by the overflow channel from the flotation unit. Some hydraulic head benefit is obtained from the air lift pumping effect in the shaft. There is also potential for lowering the Deep Shaft gradient requirement by redesigning the constant flow regulating system. This would make the hydraulic gradient requirement by the Deep Shaft Process less than that required for conventional activated sludge. Depending upon the form of the redesign, the CIL process may require even less hydraulic gradient than an extended aeration plant.

The CIL flotation tank at Paris is compared to the London, Ontario flotation units used for sludge thickening. Generally, the CIL unit has less polymer added per ton of SS, shorter detention and lower solids loading than the London units. Also, the CIL unit has higher hydraulic loading, effluent suspended solids and float concentration. The most significant design

difference between the units is that the CIL unit does not have a pressurized recycle. Therefore, the CIL flotation unit did not have a recycle pump or an air compressor. This results in a saving of 20 HP for a flotation unit to handle 100,000 gpd influent. In conventional flotation units, the recycle is used to dissolve the air subsequently used to float the solids. The bubbles are supplied to the CIL flotation unit by the shaft aeration system which is therefore used for aeration, pumping and flotation. Assuming thickened sludge is required, the resulting saving of energy may exceed the extra HP needed by the shaft for aeration.

The CIL float concentration of suspended solids is substantially higher than that from the London sludge thickening unit. If float was wasted, it would not need further thickening before dewatering. Cost savings may result at locations where thickening and dewatering are needed. Possible savings were not investigated due to the preliminary nature of the study, and also because float wasting was not practiced at Paris.

Another factor of note is that the London units are reported as producing an effluent with suspended solids level more than 50% lower than the CIL unit. Although the London figure of 25 mg/l still exceeds the MOE objective for discharge to a receiver, it does indicate that flotation can produce a substantially better "effluent" than the CIL unit does.

The Deep Shaft Process at Paris had an installed horsepower of 40 3/4 HP made up of 2 HP for foam breakers, 30 HP for the air compressor, 5 HP for the sludge wasting pump, 1 3/4 HP for polymer handling and 2 HP for

the flotation tank scrapers. CIL personnel have stated that the compressor installed at their Paris plant is oversized but they have not indicated the degree of the oversizing. The Wastewate Treatment Section has estimated that the size of the compressor required to run the shaft would be 15 HP. This estimate reduces the CIL plant requirements to 26 HP. Comparable installed horsepower for conventional and extended aeration plants is about 10 HP. This is made up of 2 HP per clarifier, 3 HP for sludge return and wasting and 3 to 5 HP for aeration. In addition, for the CIL plant, there are extra power requirements associated with the building housing the equipment, e.g. for lighting and ventilation.

The above comparison of the CIL Deep Shaft Process at Paris with conventional treatment is done to illustrate differences and similarities. This limited comparison illustrates that the CIL Deep Shaft Process, as constructed at Paris, has relatively high operating costs when compared to standard biological treatment.

APPENDIX 11.2

COMMENTS AND OBSERVATIONS OBTAINED

FROM THE PHASE I PRELIMINARY INVESTIGATION

OF THE CIL DEEP SHAFT PROCESS

The following comments and observations were made during the three week preliminary evaluation of the CIL Deep Shaft process in Paris:

1. Results of sampling and analyses by CIL for the month of May are presented in Table 13. These analyses cover 27 days of the month of May and result in an average effluent SS of 31 mg/l and BOD_5 of 28 mg/l. The WWT analyses for the month of May covered only 14 days and resulted in average effluent values of SS - 34 mg/l and BOD_5 - 25 mg/l. The average effluent quality for the CIL results for the same days are SS - 38 mg/l and BOD_5 - 36 mg/l. The reason for the discrepancy of the BOD_5 results is not known.

2. A general observation is that the CIL staff operate the biological process as if it was a chemical process. Operational changes are made almost daily and frequently multiple changes are made in one day. Therefore, the biological process seldom had a chance to stabilize.

3. During operation, continuous operator attention is required to ensure that samples, acid addition and polymer addition are correct. On frequent occasions, the process has been upset during the night when the operator was not present. Upsets can take many different forms, the most frequent being:

   - all solids sinking instead of floating,
   - rags plugging valves and cutting off flow,
   - circulation stopping in shaft.

TABLE 13

CIL RESULTS FOR DEEP SHAFT PROCESS IN MAY, 1977

	Influent			Effluent		
Date	SS	BOD_5	Sol. BOD_5	SS	BOD_5	Sol. BOD_5
1	124	90	19	18	11	8
2	194	195	84	32	32	22
3						
4						
5						
6	209	116	24	19	18	10
7				16	19	9
8				21	13	8
9	229	182	86	34		24
10	182	180	86	38	58	50
11	291	224	91	52	56	39
12	218	204	86	94	85	43
13	226		43	29	23	12
14	193	141	24	14	15	4
15	176	116	20	14	12	10
16	314	195	92	38	34	25
17	191	169	84	37	32	19
18	233	180	93	47	38	24
19	208	213	114	30	35	21
20	219	102	23	32	19	6
21	117	107	23	19	11	5
22	139	102	20	22	11	7
23	117	113	13	19	11	9
24	208	160	76	49	40	22
25	270	167	77	23	22	14
26	203	202	85	42	39	24

*All results in mg/l

Table 13 - cont'd

	Influent			Effluent		
Date	SS	BOD_5	Sol. BOD_5	SS	BOD_5	Sol. BOD_5
27				28	24	12
28				17	9	6
29				17	8	7
30	456	262	96	30	31	19
31	209	204	92	45	42	
Average	217	165	63	31	28	17
Range	117-456	90-262	13-114	14-94	8-85	4-50

4. The May 16th sample was submitted for a broad spectrum heavy metal scan and for concentrations of Pb, Cu, Zn and Hg. No significant heavy metals concentrations were noted.

5. Based on visual observations and periodic pH checks, the constant flow regulator and neutralization worked well. Influent flow is generally controlled at just above 5.25 l/sec (100,000 gpd) and at pH 7.0 $\pm$.

6. On May 18, influent temperature during the day varied between 13 and $19^{\circ}C$ (56 and $66^{\circ}F$).

7. Polymer dosage was varied from 2 mg/l to 22 mg/l during the study but a dosage of about 10 mg/l appeared to give the best effluent. Therefore, the polymer costs about $7,000 per year at 10 mg/l in a flow of 5.25 l/sec. This is equivalent to 4¢/cubic meter (19¢/1000 gallons).

8. Housekeeping at the deep shaft plant has been minimal and may be contributing to solids handling and effluent clarification problems. For example, flotation unit scraper blades are not cleaned so sludge accumulates on the blades and can be shaken loose into the overflow (beach and channel). Also, the bottom well of the flotation unit has sludge hanging up on the sides. These solids can become septic.

9. During upsets when all solids sink instead of floating, sludge return can become plugged or is so slow that the solids all end up in the flotation cell. The shaft then has minimal MLSS. During the time that it takes to regain a float and adequate MLSS, the effluent quality can deteriorate and sludge can go septic. Also, during such times, the flow patterns of the flotation tank can change and result in sludge wasting to the effluent.

10. A certain amount of skill is required to operate the plant, particularly during upsets. Also, frequent operator attention is required because with an upset at such a low detention time there is minimal buffer capacity and time for operator reaction. Very significant upsets did occur within one hour without prior warning.

11. Plugging of head works piping and valving at the top of the shaft has been a problem. There has been no apparent problem with plugging of the bottom of the shaft, but this could not be directly determined.

12. Foaming in the shaft head works had been a problem until mechanical foam breakers were installed and the problem was apparently solved.

13. Amount of polymer addition is determined by a visual observation of the float. Polymer adjustment is therefore still an art. The polymer currently being used is Percol 757 or Praestol 423K. Various other polymers were tried and rejected.

14. Analyses of influent and effluent were also made for NH_3-N, NO_2-N, NO_3-N, Soluble P, Alkalinity and Volatile Solids. Results are not noted in this report because a detailed discussion of these parameters was not considered necessary.

15. The CIL continuous pH and flow recorders are not reliable due to malfunctions and inaccuracies of equipment.

16. Air supply to the shaft was generally 934 l/min (33 SCFM) in the downer and 310 l/min (11 SCFM) in the riser. When the shaft "stalled" all the air would be manually shut off and flow re-established. (Note procedure outlined in Comment 3 of Appendix 11.3).

17. *Physical and process conditions in the shaft will be very difficult to determine as would be needed for normal plant operation or an MOE process evaluation. For example, it was not possible to determine if solids were collecting in the bottom of the shaft, if rags were accumulating on the shaft air pipes or what the dissolved oxygen level was at any point in the shaft.*

18. *Polymer feed uses carrier water after the polymer metering pump. This water comes from the municipal water supply and is controlled at 9.1 l/min (2 gpm) by a dole valve. This is a flow of about 13 cubic meters/day (3,000 gpd) or 3% of the flotation tank effluent.*

19. *A dye was added to the downer side of the head works and the time taken for dye to appear in the riser head works was noted. This took 5-3/4 minutes. Assuming that the cross-sectional area of the downer and the riser are equal and that the flow travels 304 meters (1,000 ft), the mean velocity around the shaft was 0.88 m/sec (2.5 ft/sec).*

20. *The sequential samples would take an aliquot twice every hour. These samples were then hand composited into two 12-hour composites and one 24-hour composite. From each of these composites, CIL and WWT would each take a portion for analysis. This method suffered because the bucket used for mixing sequential samples was not always cleaned by the CIL staff between compositings. Settling and flotation during sample pouring were also a problem.*

21. The results for the 12-hour composite samples are in Tables 14 and 15. Generally, removal efficiencies are better during the daytime and this is probably due to an operator being present.

22. Influent pH to the Paris WPCP varied between 7.5 and 10. Figure 5 is a typical weekday recording of the influent pH at the grit channel. During periods when the textile plant is shut down, midnight to 8 a.m. and weekends, the pH is relatively constant around pH 8. Occasionally, the pH will jump 1 to 1 1/2 units in a few minutes. In Figure 5, this occurred at 13:20. Other fluctuations are more gradual but cover a wider range.

TABLE 14

COMPARISON OF PHASE I 12-HOUR COMPOSITE SAMPLES OF CIL INFLUENT AND EFFLUENT FOR 9 am to 9 pm

Date	BOD_5 mg/l INFL.	BOD_5 mg/l EFFL.	BOD_5 % REMOVAL	SOLUBLE BOD_5 mg/l INFL.	SOLUBLE BOD_5 mg/l EFFL.	SOLUBLE BOD_5 % REMOVAL	SUSPENDED SOLIDS mg/l INFL.	SUSPENDED SOLIDS mg/l EFFL.	SUSPENDED SOLIDS % REMOVAL
May 10	180	22	88	70	17	76	243	22	91
May 11	154	21	86	70	9	87	184	32	83
May 12	220	34	85	93	18	81	248	48	81
May 13	158	52	67	83	28	66	480	63	87
May 14/15	140	22	84	36	9	75	244	31	87
May 17	240	41	83	100	13	87	412	28	93
May 18	144	25	83	78	11	86	232	18	92
May 19	159	25	84	70	9	87	-	-	-
May 20	128	17	87	51	9	82	-	-	-
May 24	95	7	93	20	5	75	206	10	95
May 25	190	25	87	83	13	84	296	26	91
May 26	140	-	-	86	-	-	346	-	-
May 27	190	19	90	63	10	84	199	19	95
Average	164	26	84	69	12.6	82	281	30	89

TABLE 14 (cont.)

	COD mg/l			KJELDAHL NITROGEN mg/l			TOTAL PHOSPHORUS mg/l		
	INFL.	EFFL.	% REMOVAL	INFL.	EFFL.	% REMOVAL	INFL.	EFFL.	% REMOVAL
May 10	708	113	84	33	17	48	6.4	0.52	92
May 11	459	65	86	30	18	40	5.1	0.4	92
May 12	779	177	77	36	21	42	6.1	1.1	82
May 13	539	220	59	30	26	13	5.7	3.2	44
May 14/15	415	90	78	34	19	44	6.0	0.75	88
May 17	825	161	80	39	19	51	7.8	0.60	92
May 18	325	21	94	29	16	45	5.4	0.5	91
May 19	439	36	92	36	20	44	6.2	0.85	86
May 20	338	144	57	31	14	55	8.4	0.56	93
May 24	337	-	-	30	14	53	5.9	0.22	96
May 25	734	-	-	34	17	50	6.2	0.76	88
May 26	683	-	-	30	-	-	4.8	-	-
May 27	721	167	77	34	19	44	7.8	0.2	97
Average	562	119	79	33	18	45	6.3	0.8	87

TABLE 15

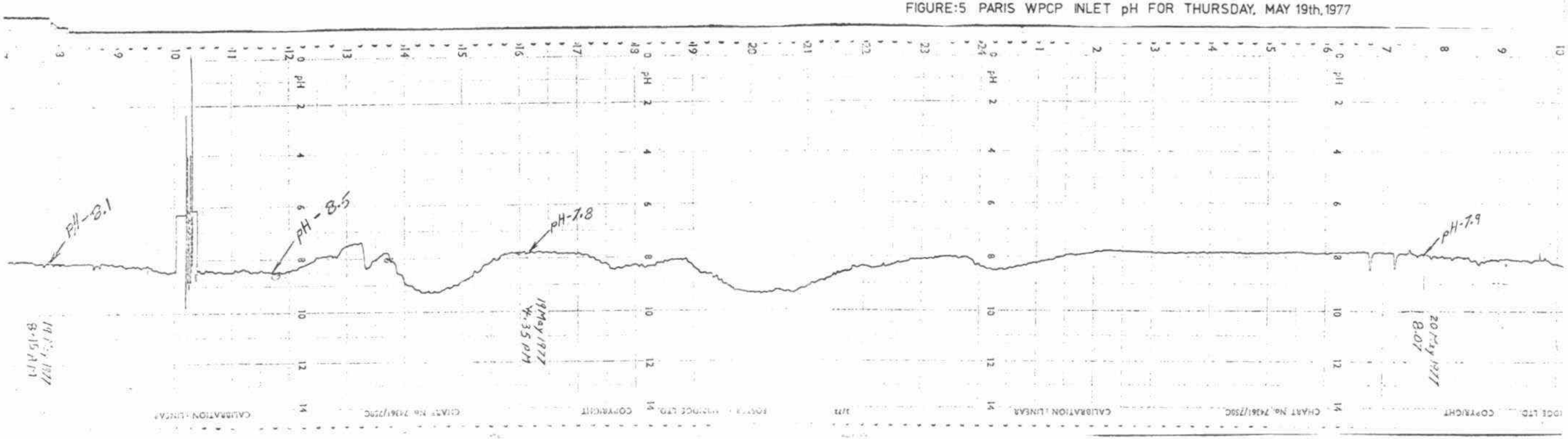
COMPARISON OF PHASE I 12-HOUR COMPOSITE SAMPLES OF CIL INFLUENT AND EFFLUENT FOR 9 pm to 9 am

Date	BOD_5 mg/l			SOLUBLE BOD_5 mg/l			SUSPENDED SOLIDS mg/l		
	INFL.	EFFL.	% REMOVAL	INFL.	EFFL.	% REMOVAL	INFL.	EFFL.	% REMOVAL
May 10	86	19	78	46	12	74	150	18	88
May 11	134	46	66	65	31	52	142	52	63
May 12	133	33	75	58	20	66	202	43	79
May 13	138	54	61	73	24	67	174	95	45
May 14/15	103	18	83	25	19	64	188	12	94
May 17	123	31	75	58	15	74	115	41	64
May 18	166	35	79	79	16	80	157	30	81
May 19	90	20	78	57	8	86	-	-	-
May 20	143	21	85	71	12	83	-	-	-
May 24	78	6	92	14	5	64	178	9	95
May 25	74	30	59	60	18	70	147	43	71
May 26	105	-	-	67	-	-	167	-	-
May 27	106	26	75	64	11	83	174	60	66
Average	114	28	75	57	16	72	163	40	75

TABLE 15 (cont.)

Date	COD mg/l			KJELDAHL NITROGEN mg/l			TOTAL PHOSPHORUS mg/l		
	INFL.	EFFL.	% REMOVAL	INFL.	EFFL.	% REMOVAL	INFL.	EFFL.	% REMOVAL
May 10	304	61	80	23	10	57	3.8	0.34	91
May 11	316	196	40	27	19	30	6.5	2.2	66
May 12	661	182	42	27	14	48	7.5	1.3	83
May 13	490	293	40	26	18	31	5.4	2.4	56
May 14/15	428	-	-	32	18	44	6.1	0.58	90
May 17	545	84	85	27	12	56	4.2	0.75	82
May 18	296	32	89	23	11	52	4.1	0.7	83
May 19	275	53	81	24	12	50	6.4	1.0	84
May 20	431	167	61	27	10	63	7.1	0.82	88
May 24	-	-	-	25	18	28	4.6	0.26	94
May 25	522	-	-	22	11	50	3.8	1.1	71
May 26	551	-	-	24	-	-	3.8	-	-
May 27	564	244	57	25	17	32	6.8	1.9	72
Average	449	146	67	26	14	46	5.4	1.1	80

FIGURE:5 PARIS WPCP INLET pH FOR THURSDAY, MAY 19th, 1977



APPENDIX 11.3

COMMENTS AND OBSERVATIONS OBTAINED FROM
THE PHASE II PRELIMINARY INVESTIGATION OF
THE CIL DEEP SHAFT PROCESS

The following comments and observations were made between the period of July 13 to August 5:

1. Polymer concentration in the influent to the flotation tank was changed as judged necessary by the operators. This judgment was based primarily on how the float looked in the aeration tank and how the MLSS from the head works behaved in a beaker. Degree of adjustment appeared to be based on guesses by the operator.

2. Polymer feed rate was determined by measuring flow out of the conveyance tube. This test is suspect because only the polymer pump was used during the test, whereas carrier water is added after the pump. This difference in procedure may affect the delivery rate of the polymer.

3. Shaft startup procedure is to fill it with water or sewage and turn on riser air at 480 l/min (17 SCFM). This starts fluid flow through the shaft. After 10 minutes, about 284 l/min (10 SCFM) of air is introduced into the down comer. Then, at five-minute intervals, the down comer airflow is increased by 142 l/min (5 SCFM) until 934 l/min (33 SCFM) is being used. The whole procedure to restart the shaft takes about 30 to 40 minutes. When the shaft is stalled, influent is shut off until motion through the shaft is restarted.

4. Microscopic examinations of MLSS were periodically made. Very few higher life forms were observed and then only one or two protozoa or ciliates. The observer was unable to determine whether these were alive or dead.

5. Flow through the shaft stopped on occasions due to: plugged raw sewage line, shaft backup, power failure.

6. Top and bottom rake speeds on the float tank were adjusted based on the amount of return sludge desired. Decision was based on visual observation of the process.

7. Flow was shut off to the deep shaft for two hours on August 21 due to work being done on the Paris WPCP. WWT staff viewed the CIL process five hours later and visually the shaft did not appear to have completely recovered. The Process was next observed by WWT staff at 8 a.m. on August 22 and seemed to have recovered.

8. Large sludge pieces were occasionally carried into the effluent. These broke up completely in the short fall into the effluent channel.

9. CIL attempted to run the shaft at a MLSS of 5,000 to 6,000 mg/l. A controlled range appeared to be difficult to maintain. The MLSS in the shaft could be adjusted by changing the flotation tank water level, rake speed or sink pumping rate. Sample results of MLSS are in Table 10 and show the variability encountered.

10. On July 28, dissolved oxygen concentrations were determined. The raw sewage had 7.5 mg/l, the head tank 9.0 mg/l and the flotation tank had 4.8 mg/l. This indicates that 4.2 mg/l of dissolved oxygen was lost in the flotation tank. A part of this would be due to biological activity because the shaft effluent had a respiration rate of 68 mg O_2/l/hr. This rate would be expected from a high rate process.

11. On two occasions, wastes from a chicken processing plant were observed. This took the form of blood, feathers, chicken parts and bits of fat. On one occasion, the parts were thought to have plugged the CIL gate valve which controls quantity of influent to the shaft.

12. On August 1st, CIL tried an anionic polymer for 3 1/2 hours. No special effluent sampling was attempted to determine the effect. This polymer was supposed to react well due to the alum in the system.

13. On one occasion, an adequate float blanket disappeared within 30 minutes.

14. No neutralization was done in Phase II when the textile plant was not operating.

15. A sudden change of the down comer air can cause the circulation in the shaft to reverse. This results in a "burp" which sometimes spews mixed liquor out of the shaft. Shaft circulation then has to be restarted in the previously described manner.

16. When the textile plant came back on stream, polymer concentration was increased from 2-12 mg/l to 20-22 mg/l. As the WWT study had been completed, samples were not taken but effluent quality looked very poor.

17. Improved housekeeping of CIL deep shaft equipment may improve process performance. This is most noticeable in the flotation unit where cleaning of the sludge hopper and rakes would be of benefit.

18. The entrance port to the flotation unit became constricted with densely packed sludge. Buildup was thick enough to require a shovel to remove the sludge.

19. The CIL sampling results for Phase II are in Table 16.

20. A continuous recording pH meter was put into service in the grit channel of the Paris WPCP. Recordings were made from June 29 to August 4. For the Phase II period, the pH was predominantly about 8.0. The range was from 7.5 to 8.5 and on one occasion jumped very quickly from 7.5 to 8.5. When the textile plant resumed operations, the pH became much more erratic and varied from 8 to 10.

21. Starting at 11 a.m., July 27, CIL took hourly effluent samples until 10 a.m. July 28. The results of MOE analysis are in Table 17. This sampling was done to investigate the deep shaft process upset which reportedly occurred every night between 1 a.m. and 4 a.m.. These upsets were thought to be the cause of the poorer effluent samples during the nighttime. No upset was apparent from the analytical results.

22. The analytical results for the 12-hour composite samples are given in Tables 18 and 19. As in Phase I, the removal efficiencies are generally better during the daytime than the nighttime. During the period of continuous operating supervision, the effluent quality was relatively uniform throughout the day. This tends to support the conclusion that continuous supervision is a benefit.

TABLE 16

ANALYSES RESULTS FOR PHASE II OF THE PRELIMINARY STUDY BY CIL

	Influent Concentration mg/l				Effluent Concentration mg/l			Removal %	
Date	S.S.	BOD	SOL. BOD	MLSS mg/l	S.S.	BOD	SOL. BOD	BOD	S.S.
July 16	167	102	15	7,274	14	12	5	88	92
July 17	270	132	21		16	11	5	92	94
July 18	648	204	28	7,558	20	28	9	86	97
July 19	220	124	25	7,150	16	14	4	89	93
July 20	238	124	18	3,169	51	17	2	86	79
July 21	372	147	16	3,640	83	65	2	56	77
July 22	254	120	30	4,593	55	41	1	66	78
July 23	159	110	17		125	43	5	61	21
July 24	235	133	30		40	38	2	71	83
July 25	331	135	22	3,264	26	34	6	75	89
July 26	185	134	24	3,581	24	42	5	69	87
July 27	199	115	30	5,975	28	36	6	69	86
July 28	189	132	24		23	13	1	90	88
July 29	235	131	21		13	13	2	98	95
July 30	242	133	28		74	5	2	96	69
July 31	298	134	16		18	8	3	94	94
Aug. 1 *	94				20				
Aug. 1	314				135				
Range	94-648	102-204	15-30		13-135	5-43	1-9	56-98	21-97
Average	258	132	23		43	26	4	80	83

*Grab sample, all other samples are 24-hour composites.

TABLE 17

PHASE II

CIL DEEP SHAFT EVALUATION: HOURLY EFFLUENT SAMPLES OVER 24-HOUR PERIOD

Date - July 27-28/77

Hour	BOD_5 mg/l	SOL. BOD_5 mg/l	SUS. SOL. mg/l	VOL. S.S. mg/l
11 am	-	3	6	6
12 noon	-	3	10	9
1 pm	24	3	32	25
2 pm	20	3	19	16
3 pm	-	>27	9	8
4 pm	54	>34	24	20
5 pm	35	21	21	18
6 pm	35	18	30	25
7 pm	-	12	21	18
8 pm	20	4	24	18
9 pm	20	4	29	22
10 pm	20	4	27	21
11 pm	22	3	28	21
12 midnight	24	4	35	27
1 am	18	2	25	19
2 am	18	3	30	23
3 am	-	2	10	9
4 am	-	3	10	9
5 am	-	3	6	5
6 am	15	3	19	15
7 am	-	2	8	7
8 am	-	2	12	9
9 am	-	2	8	7
10 am	-	2	5	5

TABLE 18

TWELVE-HOUR COMPOSITES FROM 9 AM TO 9 PM FOR PHASE II OF PRELIMINARY STUDY

Date	BOD5 mg/l			SOLUBLE BOD5 mg/l			SUSPENDED SOLIDS mg/l		
	INFL.*	EFF.	% REMOVAL	INFL.*	EFFL.	% REMOVAL	INFL.*	EFFL.	% REMOVAL
July 18	135	36	73	52	-	-	177	-	-
July 19	165	29	82	38	-	-	221	-	-
July 20	170	49	71	36	5	86	255	23	91
July 21	363	66	82	30	9	70	436	40	91
July 22	127	13	90	33	5	85	219	99	55
July 23	103	15	85	29	2	93	165	170	-3
July 24	-	22	-	-	3	-	-	109	-
July 25	195	33	83	33	6	82	300	26	91
July 26	179	133	26	35	24	31	215	16	93
July 27	180	44	76	53	14	74	246	20	92
July 28	180	25	86	41	3	93	203	24	88
July 29	121	105	13	26	2	92	173	16	91
July 30	136	6	96	34	4	88	244	8	97
July 31	126	6	95	19	4	79	193	10	95
Aug. 1	118	57	53	19	14	26	213	72	66
Average	164	44	73	32	7	79	236	44	82

* Influent refers to sample taken after CIL's equalization

TABLE 18 (cont.)

Date	COD mg/l			KJELDAHL NITROGEN mg/l			TOTAL PHOSPHORUS mg/l		
	INFL.*	EFFL.	% REMOVAL	INFL.*	EFFL.	% REMOVAL	INFL.*	EFFL.	% REMOVAL
July 18	182	42	77	27	14	48	6.0	1.0	83
July 19	270	37	86	36	16	64	6.0	0.48	92
July 20	300	42	86	38	28	26	6.4	0.56	91
July 21	570	51	91	22	24	-9	5.1	3.7	27
July 22	200	28	86	29	16	45	5.8	0.52	91
July 23	160	52	67	30	20	33	6.0	0.84	86
July 24	-	53	-	-	21	-	-	1.5	-
July 25	385	48	87	35	16	54	6.8	0.44	93
July 26	240	25	90	38	17	55	6.2	0.4	93
July 27	327	37	89	36	17	53	6.4	0.24	96
July 28	280	35	87	36	19	47	6.4	0.4	94
July 29	230	214	7	30	15	50	6.1	0.22	96
July 30	260	27	90	34	18	47	7.3	0.22	97
July 31	240	24	90	33	19	42	6.9	0.26	96
Aug. 1	232	87	63	33	23	30	7	2	68
Average	277	53	81	33	19	43	6	0.8	87

TABLE 19

TWELVE-HOUR COMPOSITES FROM 9 PM TO 9 AM FOR PHASE II OF PRELIMINARY STUDY

Date	BOD_5 mg/l INFL.*	BOD_5 mg/l EFFL.	BOD_5 % REMOVAL	SOLUBLE BOD_5 mg/l INFL.*	SOLUBLE BOD_5 mg/l EFFL.	SOLUBLE BOD_5 % REMOVAL	SUSPENDED SOLIDS mg/l INFL.*	SUSPENDED SOLIDS mg/l EFFL.	SUSPENDED SOLIDS % REMOVAL
July 18	> 800	23	-	63	-	-	1,437	-	-
July 19	175	20	89	30	-	-	197	-	-
July 20	120	78	35	17	4	76	193	64	67
July 21	93	98	-5	21	5	76	125	108	14
July 22	84	24	71	44	3	93	214	127	41
July 23	93	61	34	26	2	92	155	311	-101
July 24	-	16	-	-	2	-	-	26	-
July 25	90	22	76	17	4	76	136	37	73
July 26	87	48	45	16	5	69	145	12	92
July 27	92	21	77	16	4	75	123	21	83
July 28	120	9	93	18	2	89	127	9	93
July 29	148	5	97	24	2	92	277	8	97
July 30	111	10	91	21	3	86	238	9	96
July 31	85	8	91	13	2	85	186	10	95
Aug. 1	111	86	23	14	6	57	221	157	29
Average	108	35	68	24	3	87	180	69	62

* Influent refers to sample taken after CIL's equalization

** Data for July 18th are not included in the averages

TABLE 19 (cont.)

Date	COD mg/l INFL.*	COD mg/l EFFL.	COD mg/l % REMOVAL	KJELDAHL NITROGEN mg/l INFL.*	KJELDAHL NITROGEN mg/l EFFL.	KJELDAHL NITROGEN mg/l % REMOVAL	TOTAL PHOSPHORUS mg/l INFL.*	TOTAL PHOSPHORUS mg/l EFFL.	TOTAL PHOSPHORUS mg/l % REMOVAL
July 18	1,306	39	-	70	13	-	11.0	0.96	-
July 19	232	35	85	29	15	48	5.2	0.32	94
July 20	230	70	70	27	18	33	5.0	1.7	66
July 21	155	110	29	3.4	37	-988	3.1	8.3	-168
July 22	157	82	48	26	19	27	4.0	1.6	60
July 23	135	165	-22	26	28	-8	4.6	5.0	-8
July 24	-	35	-	-	15	-	-	0.68	-
July 25	125	66	47	21	13	38	3.6	0.84	77
July 26	130	21	84	26	16	38	4.0	0.24	94
July 27	162	35	78	25	15	40	4.0	0.44	89
July 28	147	25	83	24	17	29	4.0	0.2	95
July 29	300	24	92	36	16	56	8.1	0.2	98
July 30	210	27	87	28	16	43	6.1	0.2	97
July 31	140	27	81	21	14	33	4.7	0.18	96
Aug. 1	196	144	27	28	21	25	5.9	3.9	34
Average**	178	64	64	27	19	30	4.8	1.7	65

* Influent refers to sample taken after CIL's equalization

** Data for July 18th are not included in the averages